The Papua and New Guinea Agricultural Journal

Vol. 9 January, 1955 No. 3

Department of Agriculture, Stock and Fisheries,
Port Moresby

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All communications should be addressed to the Editor, *The Papua and New Guinea Agricultural Journal*, Department of Agriculture, Stock and Fisheries, Port Moresby.

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Commencing with Volume 9, No. 1, *The Papua and New Guinea Agricultural Journal* will be the title for the former publication *Papua and New Guinea Agricultural Gazette*. The publication will still follow the form of the pre-war *New Guinea Agricultural Gazette* and will deal with recent advancement in tropical agriculture and act as an extension medium for the dissemination of agricultural information to the Territory planting and farming community.

Members of the public are invited to submit items of tropical and general interest to agriculturalists in the Territory. Articles from interested persons outside the Territory will be appreciated.

The Annual Subscription payable in advance will be 1s. 6d. postage paid for each issue or 6s. per annum for four issues.

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The

Papua and New Guinea

Agricultural Journal

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FORMER ISSUES OF *GAZETTE*

The following numbers of the *Agricultural Gazette* have been issued:

New Guinea Agricultural Gazette—

Volume 1, Number 1.
Volume 2, Numbers 1, 2 and 3.
Volume 3, Numbers 1 and 2.
Volume 4, Numbers 1, 2, 3 and 4.
Volume 5, Numbers 1, 2 and 3.
Volume 6, Numbers 1, 2 and 3.
Volume 7, Numbers 1, 2, 3 and 4.

The Papua and New Guinea Agricultural Gazette—

Volume 8, Numbers 1, 2, 3 and 4.

The Papua and New Guinea Agricultural Journal—

Volume 9, Numbers 1, 2.

Copies of all numbers of the *Gazette* to Volume 7, No. 4, are out of print.

The Papua and New Guinea
Agricultural Journal

Vol. 9 **January, 1955** **No. 3**

THE COSTS OF MECHANIZED AGRICULTURAL OPERATIONS IN THE MEKEO DISTRICT OF PAPUA

T. SORENSEN, B.Sc. (Agr.)*

THE labour resources of the Territory of Papua and New Guinea are limited and considerable interest is being shown in the possibility of introducing mechanization not only to reduce costs but also to enable the labour force to be used to the maximum extent for those operations which cannot be mechanized. Little experimental work has been carried out with regard to the suitability of various types of machinery to Territorial conditions; Australian experience does not necessarily apply fully in the Territory where different soils, vegetation and climatic conditions are encountered. During the past three seasons mechanical operations have been costed at the Department's Experiment Station at Epo and the results are presented in this article.

The Lowlands Experiment Station at Epo comprises about 2,000 acres of flat grassland country with very little timber except on the creek banks. The soil is a clay loam, primarily of alluvial origin. The dominant species is cane grass (*Saccharum* spp.) with a variable mixture of other species, particularly kunai (*Imperata arundinacea*). The average annual rainfall is between 50 and 60 inches with a marked dry season extending from about May to November-December. The Station is the main rice-breeding centre for the Territory and 200-300 acres of rice are grown annually in the course of experimental work. All operations are mechanized as fully as possible, although a little hand labour is used for weeding in certain experimental plots and also during harvesting operations. All rice varieties and strains yet tested in the Territory lodge badly and the selection of non-lodging varieties is the first objective of the rice-breeding programme, in order that harvesting may be fully mechanized. The Department is also experimenting with different types of harvesting machinery in an endeavour to find machines which will handle lodged crops reasonably well.

The figures presented cover operational costs only. They do not include freight and transport of machinery, costs of major overhauls or depreciation. All ordinary running repairs are included as they occurred. Costs of fuels, oils and lubricants are based on Port Moresby retail prices in 44-gallon drum lots and do not include freight. Costs of Native labour include the wages paid, proportion of leave pay where applicable, rations and issues. Costs of recruiting, transport and housing, because they vary so much from place to place, have not been included.

The general service cost includes all routine servicing such as refuelling, oil changes, greasing, minor running repairs, etc.

* Formerly O.I.C., Experimental Station, Epo, since resigned from the Department.

TABLE 1. 40 H.P. WHEELED TRACTOR COSTS FOR VARIOUS OPERATIONS

		Date	Diesaline Consumption	Time (Hours)			Labour (Hours)		
				Operation 11	Service 11	Total	Operator 11	Driver 11	Labour
Rice Milling Engleberg Huller		Various	67	80	8.5	88.5	88.5		354
Transport with 3-ton Trailer		Various	26.5	35.5	9.5	45.0	45.0		180
Miscellaneous		June	15	17	2	19	19		38
Ploughing to 6 in. with Shearer 4-disc	General	February	9½	13	2	15		15	15
		March	25	28	7	35		35	35
Ploughing to 9 in. with I.H.C. GL. 70 4-disc	General	Various	63	68	10	78		78	78
	Munabalunga	November	90	114	13	127		127	127
	Paddock 5	December	23	23½	2	25½		25½	25½
	Paddock 14	May	14½	22½	2	24½		24½	24½
	Paddock 14	June	16	36	2½	38½		38½	38½
	Paddock 6A	June	31	67½	5	72½		72½	72½
Ploughing to 4 in with I.H.C. GL. 90	General	Various	60	68	10½	78½		78½	78½
	Paddock 1A	November	5	6	½	6½		6½	6½
	Paddock 13	December	36	30½	3	33½		33½	33½
	Paddock 1C	December	17	19½	1½	21		21	21
	Paddock 13	January	31	35½	3½	39		39	39
	Paddock 1D	January	21	23½	2	25½		25½	25½
Harrowing I.H.C. GL. 9A	General	Various	45	61½	11	72½		72½	72½
	Paddock 3	November	15	19½	1½	21		21	21
	Paddock 1D	December	15	22	2½	24½		24½	24½
	Paddock 5	January	7	8½	1	9½		9½	9½
Rolling with 26-ft. log	Paddock 14	February	13	17½	3	20½		20½	20½
	Paddock 6A	June	27½	46½	2	48½		48½	48½
Planting rice with I.H.C. GL. 130T	General	Various	4	4·	½	4½	* 9		27
	Paddock 1C	December	10	14	1	15	15		60
	Paddock 1D	January	11½	14½	2	16½	16½		66
	Paddock 13	January	14	16½	2	18½	18½		74
Harvesting with Sunshine No. 6	General	May	5	10½	2	12½	12½		62½
	Paddock 5	May	13	15	2	17	17		85
	Paddock 1B	May	9	10	2½	12½	15		75
Harvesting rice with Case Harvester	Paddock 1C	May and June	19	51	4	55			55

* European 4½, Asiatic 4½

IN 1953-1954 SEASON

Costs (pence)						Acres	Cost per Acre	Acres per Hour	Remarks
Diesaline	General Lubricant	General Service	Costs Drivers	Cost Labour	Total				
2613	2423.2	623.20	3268.31	4842.72	13770.43	....	per hr. 14s. 4d.		
				NOT	COSTED				
				NOT	COSTED				
				NOT	COSTED				
975	848.12	218.12	583.80	478.80	3103.84	13	19s. 11d.	0.46	
				NOT	COSTED				
3510	3453.06	888.06	2188.36	1737.36	11776.84	38	25s. 10d.	0.33	Very rough country. Really tracks required.
897	711.82	183.07	425.34	348.84	2566.07	25	8s. 7d.	1.06	
565.5	681.53	175.28	408.66	335.16	2166.13	13	13s. 11d.	0.57	Land wet.
624	1090.44	280.44	642.18	526.68	3163.74	13	20s. 3d.	0.36	
1209	2044.58	525.83	1209.30	991.80	5980.51				
				NOT	COSTED				
195	181.74	46.74	108.42	88.92	620.82	5½	9s. 5d.	0.92	
1404	923.85	237.60	558.78	458.28	3582.51	40	7s. 6d.	1.31	
760.5	590.66	150.35	350.28	287.28	2139.07	18½	9s. 8d.	0.95	
1209	1075.29	276.54	650.52	533.52	3744.87	40	7s. 10d.	1.13	
819	711.82	183.06	425.34	348.84	2488.06	28	7s. 5d.	1.19	
				NOT	COSTED				
585	590.66	151.91	350.28	287.28	1965.13	30	5s. 6d.	1.54	
585	666.38	171.38	408.66	335.16	2166.58	28	6s. 5d.	1.27	
273	257.46	662.15	158.46	129.96	1481.03	12	10s. 3d.	1.41	
507	530.08	136.33	341.84	280.44	1795.69	13	11s. 6d.	0.74	
1072.5	1408.49	362.24	808.98	663.48	4315.69				
				NOT	COSTED				
390	424.06	109.06	553.95	820.80	2297.87	19	10s. 1d.	1.38	
448.5	439.20	112.96	609.34	902.88	2512.88	28	7s. 6d.	1.93	
546	499.76	128.54	683.21	1012.32	2869.83	40	6s. 0d.	2.42	
195	318.05	81.79	461.33	855.00	1911.17	....	NOT	COSTED	
507	454.35	116.85	627.81	1162.80	2868.81	9	26s. 7d.	0.60	Crop 60 per cent. lodged.
351	302.90	77.90	553.95	1026.00	2311.75	6	32s. 1d.	0.60	
741	1544.79	397.29	3639.9	752.40	7075.38	19	31s.	0.37	Crop 100 per cent. lodged lying absolutely flat on ground.

TABLE 2. 33 H.P. WHEELED TRACTOR (1) COSTS FOR VARIOUS OPERATIONS

Operation and Place		Date	Fuel gallons		Time (Hours)			Labour (Hours)			
			Petrol	Power Kero.	Operations	Service	Total	Europ. & Asiatics	Operator 11	Driver 11	Labour
Stationary Engine Engleberg Huller		Various	21	17	30	4	34		34		170
Transport with 3-ton Trailer		Various	18	273	272½	31	303½		303½		
Ploughing to 9 in. with GL. 90	General	February	¾	4	3½	1	4½			4½	4½
Ploughing to 4 in.-5 in. with GL. 90	General	Various	5	77½	71½	9½	81			81	81
	Paddock 4	November	1½	49	33½	2½	36			36	36
	Paddock 1B	November	1½	46	30½	3	33½			33½	33½
Cultivation with Gaston Scarifyer	General	February and April	4	10½	8	1½	9½			9½	9½
Harrowing with GL. 9A (twice) Tandem disc	General	Various	13	145	109½	13	122½			122½	122½
	Paddock 5	October	48		26	8½	34½			34½	34½
	Paddock 4	October	70		38	6½	44½			44½	44½
	Paddock 3	October	50		27	4	31			31	31
	Paddock 1	October	78		41½	5	46½			46½	46½
	Paddock 5C	November	¾	5	3½	¾	4¼			4¼	4¼
	Paddock 11	November	18		12	1	13			13	13
	Paddock 1C	December	¾	14	10	1	11			11	11
Mowing with GL. 25VO Mower (8 treatments)	General	May	11		10½	2	12½		12½		12½
	Airstrip	Various	96	133	161	21	182		182		182
Planting with GL. 130T.	General	Various	3½	57	41	6	47	94	47		282
	Paddock 5C	November	¾	10	6½	½	7		7		28
	Paddock 11	November	¾	12	8	1	9		9		36
	Paddock 1B	December	½	10½	7½	1	8½		8½		34
	Paddock 3	January	½	4	3	½	3½		3½		14
Harvesting with Case Header	Paddock 11	May	50¼	5	50½	5½	56	56			56
	Paddock 13	May	58		52½	3½	56	56			56
	Paddock 3	May	5		12½	½	13	13			13
	Paddock 1C	June	49		46	3	49	49			49
Harvesting with Sunshine Header	Paddock 13	May	10		9½	2	11½		11½	11½	34½

IN THE 1953-1954 SEASON

Cost (pence)									
Petrol	Power Kero.	General Lubri-cant	General Service	Driver	Labour	Total Costs	Acres	Cost per Acre	Acres per Hour
945	1028.5	216.90	144.30	1235.62	2325.60	5895.92	—	16s. 4d. per hr.	....
				NOT	COSTED				
				NOT	COSTED				
				NOT	COSTED				
67.5	2964.5	234.97	156.33	583.80	478.80	4485.90	38	9s. 10s.	1.17
67.5	2783	220.52	146.70	558.78	458.28	4234.78	22	16s.	0.72
				NOT	COSTED				
				NOT	COSTED				
2160	....	187.98	125.06	575.46	471.96	3520.46	50	5s. 10d.	1.92
3150	....	274.74	182.78	742.26	608.76	4958.54	38	10s. 10d.	1.00
2250	....	195.21	129.87	517.08	424.08	3516.24	30	9s. 9d.	1.11
3510	....	300.04	199.61	775.62	636.12	5421.39	75	6s.	1.81
33.75	302.5	25.30	16.84	70.89	61.56	510.84	9	4s. 9d.	2.57
810	....	86.76	57.72	216.54	177.84	1348.96	18½	6s. 1d.	1.54
33.75	847	72.30	48.10	183.48	550.48	1735.11	19	7s. 7d.	1.90
				NOT	COSTED				
4320	8046.5	1164.03	774.41	6721.26	2489.76	23515.96	200	9s. 9d.	1.24
				NOT	COSTED				
33.75	605	96.99	31.26	258.51	383.04	1408.55	9	13s. 0d.	1.38
33.75	726	57.84	38.48	332.37	492.48	1680.92	18½	7s. 7d.	2.31
22.5	635.25	54.22	36.07	313.80	465.12	1526.96	6	21s. 2d.	0.80
22.5	242	21.69	14.43	129.35	191.52	621.69	5	10s. 4d.	1.67
2261.25	302.5	365.12	242.90	3706.08	766.08	7643.93	18½	34s. 5d.	0.37
2610	....	379.57	252.52	3706.08	766.08	7714.25	36	17s. 10d.	0.67
225	....	90.37	60.13	860.34	177.84	1413.68	5	23s. 6d.	0.40
2205	....	332.58	221.26	3242.82	670.32	6671.98	18	30s. 10d.	0.39
450	....	68.68	45.70	616.51	471.96	1652.85	4	34s. 5d.	0.42

TABLE 3. COSTS FOR VARIOUS OPERATION

Operation	Fuel Consumption		Time (Hours)			Labour (Hours)	
	Petrol	Distillate	Operational	Service	Total	Asiatic	Native Labour
Roadwork	1	21	12½	1	13½	26	26
Transport	24½	435	234½	52	286½	286½	286½
First ploughing to 10 inches. Virgin country with Shearer Majestic 4-disc	4	96	49	21½	70½	70½	70½
	8½	182	95	17½	112½	112½	112½
First ploughing to 10 inches. Old rice land with Shearer Majestic 4-disc	4½	98	43	9	52	52	52
	1½	44	16½	4	20½	20½	20½
	4	94	78	3½	81½	81½	81½
	1	49	27	12	39	39	39
Second ploughing to 10 inches. Old rice land with Shearer Majestic 4-disc	2	59	28	2	30	30	30
	13	183	127½	26	153½	153½	153½
	4	149	100½	17	117½	117½	117½
	½	23	14½	1	15½	15½	15½
Second ploughting to 5 inches Shearer Majestic 4-disc	½	20	11½	2	13½	13½	13½
Ploughing small experimental areas	4½	79	44	5½	49½	49½	49½
Harrowing GL. 9A Tandem Disc	½	17	6½	1	7½	7½ (1 European)	7½
Planting rice GL. 130T. Combine	1	20½	13	2	15	28	60

IN THE 1952-1953 SEASON

Costs (pence)						Total Cost	Acreage	Cost per Acre	Remarks
Petrol	Distillate	General Lubricant	General Service	Asiatic	Native Labour				
	NOT	COSTED							Mainly hauling other vehicles out of bogs.
	NOT	COSTED							
369.75	7098	667.85	613.7	7056	1173.38	16978	75	18s. 10½d.	Standing cane grass 8 ft. tall. Much radiator chokage.
197.9	3822	302.4	2777.7	3261	542.3	8403	38	18s. 11d.	Soft grasses only.
65.3	1716	116	106.6	1286	213.8	3524	16	18s. 3d.	Clean ground.
174	3666	548.4	503.9	5112	850	10854	30	30s. 2d.	Dense covering of Solanum
43.5	1911	189.9	174.4	2446	406.7	5172	15	28s. 8d.	Very wet conditions.
87	2301	196.9	130.9	1881	312.8	4959	30	13s. 9d.	Soft grasses only.
565.4	7139	896.4	823.5	9629	1601	20654	70	24s. 7d.	Wet conditions.
174	5812	706.5	649.1	7370	1226	15948	75	17s. 8½d.	Heavy regen. cane grass.
21.8	897.1	102	93.7	972.1	161.6	2248	16	11s. 8½d.	Light ditto.
21.8	779.8	80.8	74.3	846.7	140.8	1948	15	10s. 9½d.	Soft grasses only.
	NOT	COSTED							
21.8	663	45.7	42	900.1	782	1751	27	5s. 5d.	Tractor overpowered for this machine.
	NOT	COSTED							

TABLE 4. 40 H.P. TRACKED TRACTOR COSTS FOR VARIOUS OPERATIONS

Operation and Place		Date	Fuel Consumption		Time (Hours)			Labour (Hours)	
			Petrol (Gals.)	Distillate (Gals.)	Oper.	Service	Total	Asiatic	Native Labour
Logging-haulage		August October	0.20	18	11	2	13		
Clearing 26-ft. log	A. Dragging Paddock 6A.	August	0.50	13	12	1.5	13.5	13.5	13.5
	B. Muna-balunga	October	0.71	53	33	3	36	36	72
Ploughing to 9 inches with 4-disc Shearer	C. Paddock 1	July	2.81	171	105	51.5	156.5	156.5	156.5
	D. Muna-balunga	October	2	148	93	14	107	107	107
	E. Paddock 11	August	1.50	45	25	5.5	30.5	30.5	30.5
	F. Paddock 3	August/ September	3	89	56	19	75	75	75
	G.Paddock 13	November	1.00	58	51	7	58	58	58
	Boundaries	August	0.50	11	8	3	11	11	
2nd ploughing 9 in. 4-disc Shearer	Paddock 1	September	2.50	176	92	31	123	123	123
	Paddock 3	October	0.50	42	26	11.5	37.5	37.5	37.5
2nd ploughing to 4 in. GL. 90	Paddock 4	October	0.50	42	27	8.5	35.5	35.5	0.20

A. Cane and kunai grasses, with only widely scattered saplings.
B. Cane and kunai grasses but many saplings, stumps and Solanum. Work abnormally slow.
C. Land heavily infested with trash, sticks and large roots.
D. Land infested with regenerating Solanum.

There are a few minor errors and inaccuracies in the costing for the following reasons :—

(*a*) The Station over the costing period frequently found it necessary to run its tractors as transport vehicles. A machine engaged in a costed operation such as ploughing might be needed urgently to travel to another Station in the area. The amount of fuel used on such transport work has only been estimated and is subject to minor inaccuracy. The error would, however, be small and does not affect the validity of the figures offered.

(*b*) Oils and greases have not been assessed separately for individual operations. Total oil consumption has been measured for each tractor over a period and the oil consumption for each operation assessed on a proportionate basis per hour. The variation in oil consumption for different operations would be small and the minor inaccuracy thus introduced can be ignored. Similarly, the same grease gun was used for greasing the prime mover and the machine it was operating and the quantities of grease used cannot be separated. Different machines use different quantities of grease but the cost of lubricants is only a minor item in any case and the small error thus introduced could not affect the results. It would not have been worthwhile to purchase a separate grease gun for each machinery unit merely to achieve pedantic accuracy on this point.

(*c*) Costs of minor running repairs such as the correction of fuel blocks and faulty ignition are presented in the tables as a general service cost and are also allotted proportionately on an hourly basis. Such minor faults are random and not specific to the particular operation which was in

IN THE 1953-1954 SEASON

Costs (pence)						Total Cost	Average	Cost per Acre	Acre per hour
Petrol	Distillate	Lubricant General	General Service	Asiatic	Native Labour				
	NOT COSTED								
21.75	507	115.63	70.62	893.43	225.18	1833.61	30	5s. 1d.	2.5
30.88	2067	317.99	194.21	2382.48	1200.96	6193.52	38	13s. 7d.	1.06
122.24	6669	1011.78	606.16	10387.17	2610.42	21406.77	75	23s. 9d.	0.48
87	5772	896.15	547.31	7081.26	1784.76	16168.48	38	35s. 5d.	0.36
65.25	1755	240.90	147.13	2018.49	508.74	4735.51	18.5	21s. 4d.	0.41
130.50	3471	539.62	329.56	4963.50	1251	10685.18	35	25s. 5d.	0.47
43.50	2262	491.44	300.16	3838.44	967.44	7902.98	42	16s. 8d.	0.72
	NOT	COSTED							
103.75	6864	886.51	541.42	8140.41	2051.64	18587.73	75	20s. 8d.	0.60
21.75	1638	250.54	153.01	2481.75	625.64	5170.69	35	12s. 4d.	0.93
0.71	1638	260.87	158.90	2349.39	592.14	5021.05	38	11s.	1.07

E. Rice trash and dense regeneration of crab grass.
F. Very clean paddock. Light regeneration of creek grasses.
G. Very clean paddock.

progress when they occurred. Other minor repairs which are specific to the particular operation, for example, the cleaning of the radiator when in trashy country, are presented as additional servicing costs for that particular operation.

The following tractors were used in costed operations :—

1. 40 h.p. Tracked Diesel.
2. 40 h.p. Wheeled Diesel.
3. 33 h.p. Wheeled (1) Kerosene.
4. 33 h.p. Wheeled (2) Kerosene.
5. 17 h.p. Wheeled Kerosene.
6. 18 h.p. Wheeled Petrol.

All Wheeled Tractors were equipped with rubber tyres.

Table 1 shows the full costing for the 40 h.p. Wheeled Tractor for all operations carried out in the 1953-1954 season. For comparison costs for various operations with the 33 h.p. Wheeled Tractor (1) are shown in Table 2.

The costs for any one season as given in Tables 1 and 2 are not necessarily fully indicative of costs over a longer period. A particular machine may in any one season be almost trouble free but then suffer a series of minor breakdowns in the following season, with a consequent increase in costs. This is well illustrated in Tables 3 and 4 which represent costs for the 40 h.p. Tracked Tractor in the years 1952-1953 and 1953-1954. This tractor was in excellent condition in 1952-1953 but was in need of overhaul in 1953-1954. The sluggishness of this unit in 1953-1954 is shown in higher costs per acre when compared with the same operations in the previous year; the very large number of hours spent in servicing in the latter year also contributes heavily to higher costs.

Tables 5-14 represent the average cost per acre of operation of all machinery combinations tried for the period from January, 1951, to June, 1954. Some combinations which were obviously uneconomic were not tried more than once, but where suitable machinery combinations were found the results have usually been taken over several seasons and should be reasonably reliable. Nevertheless, it has not always been possible to cost over a long enough period to eliminate seasonal differences and differences due to variation in soil texture, etc., and these factors account largely for apparent discrepancies.

TABLE 5. Deep ploughing, 10 inches to 12 inches virgin grass country.

Tractor	Implement			
	Shearer 4-disc Majestic	Acres Costed	I.H.C. 4-dics G.L. 70	Acres Costed
40 h.p. Tracked (A)	19s. 5d.	113	....	....
40 h.p. Wheeled (B)	19s. 11d.	14	16s. 7d.	30

(A)—Asiatic operated. (B)—Native operated.

TABLE 6. Deep ploughing. Initial opening old rice land 9 inches to 10 inches.

Tractor	Implement			
	Shearer 4-disc Majestic	Acres Costed	I.H.C. 4-dics G.L. 70	Acres Costed
40 h.p. Tracked (A)	21s.	224	....	....
40 h.p. Wheeled (B)	....	....	8s. 7d.	25
33 h.p. Wheeled (1) (B)	45s. 5d.	37	25s. 6d.	18½

(A)—Asiatic operated. (B)—Native operated.

TABLE 7. Deep second ploughing 7 inches to 9 inches.

Tractor	Implement			
	Shearer 4-disc Majestic	Acres Costed	I.H.C. 4-dics G.L. 70	Acres Costed
40 h.p. Tracked (A)	17s. 11d.	196	....	
40 h.p. Wheeled (B)	....	....	8s. 8d. (17s. 1d.)	12s. (26s.)
33 h.p. Wheeled (1) (B)	....	....	22s. 8d.	72
33 h.p. Wheeled (2) (B)	....	....	21s. 4d.	17

(A)—Asiatic operated. (B)—Native operated.

The figures in brackets were taken for wet season ploughing.

TABLE 8. Shallow ploughing 4 inches to 5 inches.

Tractor	Implement					
	Shearer 4-disc Majestic	Acres Costed	I.H.C. 4-disc G.L. 70	Acres Costed	Ferguson double mould-board	Acres costed
40 h.p. Tracked (A)	10s. 9d.	15	....	....	....	....
33 h.p. Wheeled (1) (B)	....	....	8s. 11d.	39	....	....
33 h.p. Wheeled (2) (B)	....	....	17s. 3d.	14	....	....
18 h.p. Wheeled (B)	....	....	....	....	30s. 1d.	6
	IHC 6-Furrow GL. 90		IHC 5-Furrow GL. 90		IHC 4-Furrow GL. 90	
40 h.p. Tracked (A)	11s. 8d.	73	....	....	....	....
40 h.p. Wheeled (B) ...	7s. 11d.	126½	9s. 5d.	5½	8s. 4d.	96
33 h.p. Wheeled (1) (B)	....	....	12s. 1d.	60	9s. 11d.	22
33 h.p. Wheeled (2) (B)	....	....	....	....	12s.	104

(A)—Asiatic operated. (B)—Native operated.

Notes on Ploughing Operations.—

On virgin land the first and second ploughings must be deep and thorough. The dominant species, Cane grass (*Saccharum* spp.) and kunai (*Imperata cylindrica, I. arundinacea*) have deep crowns which must be torn up and the first ploughing operation must be followed by at least two months of very dry weather to kill the crowns and persistent rhizomes. Even under the best conditions enough regrowth will occur to necessitate a second deep ploughing.

On old rice land a dense and persistent mat of soft grasses follows when the crop is removed. One deep ploughing will eradicate these weeds and also serve to bury the rice trash thoroughly. A second shallow ploughing is necessary, especially if rain occurs.

Commercial rice growers working in conditions similar to those in the Mekeo would require a heavy plough for deep cultivation and a light plough for operations just prior to planting. The 4-disc Shearer Majestic has proved very efficient for the heaviest work and is of rugged construction; the I.H.C. 4-disc GL 70 has also been very useful and is lighter than the Shearer Majestic but for that reason does not penetrate trashy ground so well in the initial ploughing.

A machine with a bigger cut is desirable for the second ploughing in order to minimize cost and the I.H.C. 4-furrow GL. 90 has proved satisfactory. However a 6-furrow implement is more economical when the draught is not too heavy for the tractors used.

A disc seeding implement would cut costs further by combining the seeding operation with the last cultivation and thus eliminate the shallow ploughing.

For all ploughing operations a heavy tractor such as the 40 h.p. Wheeled Tractor has proved to be most efficient. For initial ploughing of virgin land a tracked tractor is more suitable but if the grass is first burned the wheeled tractor is then able to handle

it. A tracked machine could probably handle a 6-disc plough, thus further increasing its efficiency.

The final operation before planting is harrowing. Costs of harrowing are shown in Table 9.

TABLE 9. Harrowing.

Tractor	Implements					
	I.H.C. GL. 9A Tandem disc	Acres Costed	Ferguson tandem disc	Acres Costed	Diamond 4-leaf	Acres Costed
40 h.p. Tractor (A)	5s. 5d.	27	....	....	.. .	....
40 h.p. Wheeled (B)	4s. 9d.	170	....	....	....	.. .
33 h.p. Wheeled (1) (B)	7s. 5d.	256	....	. .	.. .	....
33 h.p. Wheeled (2) (B)	9s.	66	.. .	....	....	....
17 h.p. Wheeled (B)	9s. 11d.	15	. ..	....	....	. ..
18 h.p. Wheeled (B)	....	....	6s. 7d.	37	32s. 8d.	1½

(A)—Asiatic operated. (B)—Native operated.

Notes on Harrowing.—

Harrowing before planting would be less necessary and could be omitted if a disc drill were used. With a tyne drill harrowing is essential as the drill will not eradicate young germinating weeds and grasses.

Again the heavier tractors, both on tracks and wheels, proved most economical for harrowing operations. The diamond tyne drag harrows proved too heavy for the light tractor and considerable wheel slip occurred. Wheel weights would possibly have overcome this difficulty. The same tractor could handle the Ferguson disc-harrows quite well on this country and operated them fairly economically.

The next operation is planting and costs as shown in Table 10.

TABLE 10. Planting.

Tractor	Implement			
	GL. 130 T. I.H.C. Drill	Acres Costed	GL. 130 T. Drill plus GL. 9A Harrow	Acres Costed
40 h.p. Wheeled (B)	6s. 4d.	187	.. .	
33 h.p. Wheeled (1) (B)	10s. 7d.	107½	10s. 11d.	13½
33 h.p. Wheeled (2) (B)	7s. 10d.	74	14s. 5d.	70

(B)—Native operated.

Notes on Planting.—

The only seeding implement used was the I.H.C. GL. 130T. Combine. It has proved unsatisfactory on this type of country, as would any tyned machine, owing to its tendency to choke on trashy country. Only a disc-seeder will handle these conditions satisfactorily and the use of such a machine would no doubt prove to be much more economical, especially as it would probably eliminate the need for one working prior to seeding.

However, with the machinery available the 40 h.p. Wheeled Tractor again proved its superiority over the other prime movers used.

Tables 11 and 12 present the results for various tractor and harvester combinations.

TABLE 11. Rice Harvesting—Case Header.

Condition of Crop	Tractor			
	40 h.p. Wheeled	Acres Costed	33 h.p. Wheeled (1)	Acres Costed
Erect, clean	....	....	27s. 4d.	36
100 per cent. lodged, clean	46s. 6d.	19	39s. 8d.	5
60 per cent. lodged, weedy	....	....	49s. 2d.	18½
100 per cent lodged, weedy	....	....	57s. 2d.	28

TABLE 12. Rice Harvesting—Sunshine Header.

Condition of Crop	Tractor					
	33 h.p. Wheeled (1)	Acres Costed	40 h.p. Wheeled	Acres Costed	33 h.p. Wheeled (2)	Acres Costed
Erect, clean	53s. 1d.	4	....	....	....	....
60 per cent lodged, clean	....	.. .	39s. 6d.	6	....	....
Erect, weedy	58s. 7d.	9½	37s. 9d.	9	....	....
60 per cent. lodged, weedy	60s. 8½d.	20	....	....	51s. 7d.	18

Notes on Harvesting.—

Great difficulty has always been experienced in harvesting rice mechanically as all varieties so far tried lodge to a greater or lesser extent. Almost 100 per cent. lodging of the whole crop is common. Much of the area grown at the Station, consisting as it does of small experimental plots, must in any case be harvested by hand but bulk seed is also grown. The Sunshine Header has never been able to handle really badly lodged crops and until 1953-1954 these have been harvested by hand and later threshed with the Sunshine; it is quite efficient for this purpose and will doubtless also be efficient in the field when non-lodging varieties have been produced.

The Case Harvester was in use for the first time in 1953-1954 and immediately proved to be most valuable. It will handle completely lodged crops even when dirty and it will be noted that it operated more

economically than the Sunshine in every instance where a direct comparison is possible. The Case still leaves behind too much of a badly lodged crop but it is thought that the fitting of a pick-up reel with spring steel crop lifting mechanism will give the machine added efficiency in this respect.

The only operation remaining is rice milling. The figures are given in Table 13.

TABLE 13. Rice Milling, Engleberg Rice Huller.

	40 h.p. Wheeled	33 h.p. Wheeled (1)	33 h.p. Wheeled (2)
Cost per hour	9s. 5d.	16s. 5d.	13s. 11d.
Hours costed	520	30	19

Cost per ton 1952-1953.—

40 h.p. Wheeled—£3 4s. 4d.
33 h.p. Wheeled (1)—£3 19s. 11d.
33 h.p. Wheeled (2)—£16 1s. 10d.

(Note : 33 h.p. Tractor (2) was in very poor condition at this time.)

Notes on Milling.—

Rubber-roller type mills of Japanese and British manufacture which produce brown rice are being tried at Epo but the only machine for which extensive cost figures are available is the Engleberg which produces an undermilled white rice—that is, a grain from which the germ and part of the outer layers have been removed, but not a fully polished rice. The figures again show a marked advantage in economy with the 40 h.p. Tractor as a source of power.

One other miscellaneous operation not directly connected with rice growing has been costed, namely the mowing of the airstrip. Cost figures are presented in Table 14.

TABLE 14. Mowing Airstrip.

Tractor	Implement					
	GL25VO P.T.O. Mower	Acres Costed	Ferguson P.T.O. Mower	Acres Costed	Sunshine Drawn Mower	Acres Costed
40 h.p. Wheeled (B)	....	....	..	....	8s. 5½d.	25
33 h.p. Wheeled (2) (B)	9s. 11d.	100	....	....	..	....
33 h.p. Wheeled (1) (B)	9s. 11d.	350	..	....	....	....
17 h.p. Wheeled (B)	5s. 2½d.	25	..	....	....	....
18 h.p. Wheeled (B)	....	....	4s. 7½d.	25	....	....

It is seen from Table 14 that the lighter tractors and mowers are more efficient for this operation but the lighter mowers are more susceptible to breakage in this type of country.

NOTES ON TRACTORS.

1. 40 H.P. TRACKED TRACTOR.

This machine has been on the Station since 1951. It has operated efficiently but it is considered that its power has not been fully utilized in many operations and it would be more efficient with, for instance, 6-disc ploughs rather than with the 4-disc ploughs used for the deep ploughing in this area.

For a period in June and July, 1952, the tractor was operated by Native drivers but this was not considered satisfactory and it has since been driven only by European or Asiatic staff. As all the wheeled tractors are driven by Native operators, this fact militates against economical operation of a tracked tractor.

After almost 1,000 hours' service in 1952-1953, it required minor repairs. However, this was not possible, as parts were not available and in the 1953-1954 season only 539 hours of work were done with this tractor and it was relatively sluggish and inefficient when compared with its performance in the previous season. During its period of efficient operation in 1953-1954 the general lubricant cost was 7.03 pence per hour and general service cost was 6.46 pence per hour. Operation during this period was particularly trouble free.

2. 40 H.P. WHEELED TRACTOR.

This tractor has been in use since February, 1951, and has to date completed almost 4,000 hours of service. It gave 2,800 hours of service, including 646½ hours in eleven weeks at one period, without a major overhaul or breakdown. This is the best performance so far recorded in this area. In April, 1953, a failure in the oil reticulation system caused one of the big end bearings to seize but after the replacement of the bearing and repair of the oil pump it again gave excellent service in the 1953-1954 season.

This type of tractor has proved the most economical in use at Epo for practically every operation and is rugged and simple in construction. Lubricant cost was 9.59 pence per hour from February, 1951, to July, 1953, and the general service cost was 3.73 pence per hour. This tractor is a dry sump type which accounts for the relatively high oil consumption. The simplicity of operation is reflected in the low service cost and this machine is particularly suitable for use by Native operators.

3. 33 H.P. WHEELED TRACTOR (1).

This tractor was on the Station for a number of years prior to the commencement of the costing period. Its total operational time to date is not known but it was under repair during the 1952-1953 season and did 1,099 hours' work in 1953-1954. It is not quite heavy enough for the heavier operations in this type of country and costs for most operations do not compare favourably with those obtained for the 40 h.p. Wheeled Tractor.

4. 17 H.P. WHEELED TRACTOR.

This machine was available on loan for a short time only and was in poor condition. It consumed lubricants valued at 8.95 pence per hour and service costs amounted to 12.84 pence per hour. However, these very high figures should not be taken as indicative of the true performance of the tractor owing to its need for attention at the time and the limited period of costing.

5. 33 H.P. WHEELED TRACTOR (2).

This tractor was operated only in the 1951-1952 season when it had to do the bulk of the Station work. It was in need of a top overhaul when the season began and for that reason the costs for its 1,102 hours of operation that year are higher than should normally be the case. Owing to shortage of parts at the time several minor repairs which would have improved efficiency could not be effected. When these facts are considered the performance of the tractor is seen in a better light. However, the tricycle undercarriage makes it difficult to operate under the conditions encountered at Epo and renders turning difficult whether the ground be wet or dry and powdery.

Over the costing period lubricants cost 12.51 pence per hour and overall servicing costs were 7.84 pence per hour. As already stated both these costs are abnormally high owing to the condition of the tractor.

6. 18 H.P. WHEELED TRACTOR.

This tractor is too light for large scale ploughing and cultivation activities but is an excellent machine for transport, row crop

work and similar light jobs. It was costed for only a short period before it was destroyed by a fire. During the costing period the lubricant cost was 2.90 pence per hour and the general service cost 3.32 per hour. These figures are low but the tractor was still almost a new unit when it was destroyed.

Summary and Conclusions.—

In this article costs have been calculated for all the operations in mechanized rice production at the Lowlands Agricultural Experiment Station, Epo. For the cultivation of about 300 acres of rice per year the following machinery would appear to be most suitable.

(*a*) A medium-heavy tractor. If only one unit is to be purchased it should be wheeled. The 40 h.p. Wheeled Diesel has been outstanding for performance and economy at Epo.

(*b*) A heavy plough. The 4-disc Shearer Majestic and the I.H.C. GL 70 have been tried at Epo and both performed well.

(*c*) A combined disc-cultivator and seed-drill. No such machine has been available at Epo but it should prove superior to the tyned machines used as the latter choke readily with grass and rice trash.

(*d*) A harvester. The " header " type is unsatisfactory as crops are usually badly lodged. The Case Harvester has been successful and should be further improved by the addition of a pick-up reel with spring steel crop lifting mechanism. Any machine of the " harvester " type should be suitable.

(*e*) A rice mill, if the rice is to be milled on the property. Small and cheap Japanese mills would appear to be suitable. The tractor would provide the necessary power.

(*f*) A transport vehicle.

On this basis, with rice as the only crop, the tractor would be used for about 1,250 hours per annum to perform all the normal operations necessary for the production of a 300 acre rice crop. Milling would require some hundreds of hours during the off season in addition if the rice were milled on the property.

ECONOMIC ENTOMOLOGY IN PAPUA AND NEW GUINEA 1948-1954

G. S. Dun, B.Sc. (Agr.) *

IT has been estimated that 10 per cent. of the World's agricultural potential is lost annually by the ravages of pests and diseases. Whilst the Territory of Papua and New Guinea is relatively free from many important pests and diseases, losses from these causes are still considerable, both in the field and in stored agricultural produce. A review is given here of the investigations in pest control carried out in this Territory by the Department of Agriculture, Stock and Fisheries in the postwar period, together with an indication of some of the more serious problems yet to be solved.

The main export crops of the Territory at present are coconuts, rubber and cacao. Rubber can be discounted in this summary as it appears to be singularly free from pest attack. The coconut is currently by far the most important crop and is affected by a number of pests, several of which are capable of causing severe damage. Cacao, on the other hand, is a crop relatively new to the Territory but, due to the influence of extremely high postwar prices, it is being expanded rapidly. It is affected by a large number of insect species and this list is continually being added to as indigenous species adopt it as a host plant in the newly planted areas. Brief notes on the work that has been done on the various entomological problems are appended below :—

(A) Agricultural Crops.—

1.—*Coconuts.*

The principal pests at present are the Rhinoceros Beetle (*Oryctes rhinoceros L.*), the Coconut Grasshopper (*Sexava* and *Segestes* spp.) and the Coconut Leafminer (*Promecotheca papuana* Cski.). Localized losses are also caused by *Brontispa longissima* Sharp., *Axiagastus campbelli* Dist., *Rhyncophorus* spp. *Tirathaba rufivena* Meyr., *Parasa lepida* Cram. and various other species of lesser importance.

(*a*) *Oryctes rhinoceros* is, as yet, of limited distribution in the Bismarck Archipelago and its confinement to its present distribution is a matter for considerable concern. The insect appears to have been introduced to the Territory during the Japanese occupation and is now well established on the Gazelle Peninsula of New Britain and, to a lesser extent, in parts of New Ireland. The damage is caused by the adults which eat their way into the crown of the palm and chew the unopened fronds which, when unfolded, results in a loss in leaf area ; when this is extensive the palms may be killed either directly or by the entry of secondary organisms. The larva lives as a normal White Grub in any location providing an adequate supply of organic matter in a sufficiently decomposed state. Control of the larvæ by biological means is a difficult matter as it is not known to support any specific parasites. Two Scoliid parasites of related species of *Oryctes* were collected by the writer in Zanzibar (*S. ruficornis*) and Mauritius (*S. oryctophaga*) and these have been liberated in areas of high *Oryctes* incidence in New Britain. These liberations were effected towards the end of 1952 and in mid 1953, a further shipment of *S. oryctophaga* comprising about 1,000 gravid females was obtained from the Mauritius Department of Agriculture and released in a strong condition.

The general consensus of opinion is that complementary action by parasites and predators will be required to effect any appreciable lessening of the damage. Accordingly, stocks of the predatory Histerid, *Platylister chinensis* have been obtained from Fiji and liberated in infested areas where cattle are grazed. More recently, several species of *Leionota*, also a predatory Histerid found in rotting coconut trunks, have been obtained from Trinidad and several species of a predatory Elaterid

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Fig. 1.
Typical coconut frond damage caused by "Oryctes rhinoceros" L.
(Photo J. H. Ardley)

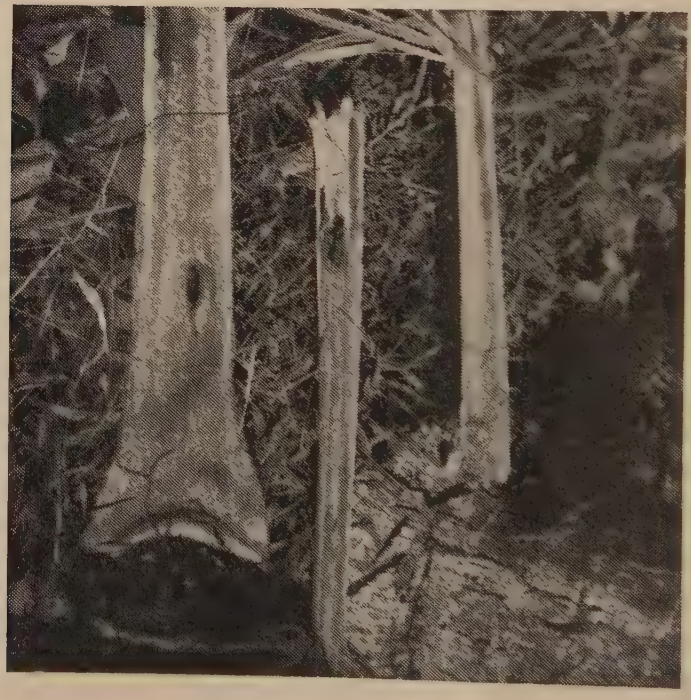

Fig. 2.
Tunnels in coconut leaf bases caused by "O. rhinoceros".
(Photo J. H. Ardley)

(*Pyrophorus*), found in similar locations are being obtained from the same source. Some general work has also been done with a local species of Dynastid (*Oryctoderus coronatus* Bates) which has the unusual habit of being predatory in the adult stage. A limited number of observations has also been made on a local species of Scoliid (*S. pulchripennis* Cameron) which is parasitic on the New Guinea Rhinoceros Beetle, *Scapanes grossepunctatus*, Sternb. The latter species incidentally is capable of causing considerable localized damage to coconuts until they reach the age of bearing. It is replaced on the Mainland of New Guinea by *S. australis* Boisd.

Control of the Rhinoceros Beetle from the chemical or general plantation sanitation angle presents considerable difficulties under post-war conditions for reasons associated with such factors as cost and scarcity of Native labour, rough terrain, heavy war damage and so on. Some experiments on trapping under strips of dead coconut trunks appear to be both uneconomic and not especially fruitful of results. Preliminary investigations of treatment of compost pits with persistent insecticides, especially gammexane, indicate that a dosage of 2 ounces per 10 cubic feet of 6.5 per cent. G.I. content will cause a reduction of up to 90 per cent. in the larval population, compared with the controls, after almost six months. These trials have recently been extended to include the use of Aldrin and Dieldrin dusts using rotted sawdust and coconut meal as the compost materials.

Hand-dusting of young Oil Palms (the only species of host readily available) with about 3 oz. of a $2\frac{1}{2}$ per cent. D.D.T. Dispersible Powder in Pyrophyllite per palm has been tried to see whether it is economically possible to obviate, in bad *Oryctes* areas, the two-three years lag in coming into bearing of young palms suffering heavy frond damage. Beetles were extracted from feeding channels in the crowns of the palms for eight months after the dust was applied. At the six-monthly examination 65 per cent. of the beetles died within 48 hours. All showed obvious D.D.T. effects for this period, but the remainder recovered and most were still alive and active a month later. It is possible that the survivors had not been feeding in the crowns sufficiently long to absorb a lethal dosage. Possibly due to rather heavy rain, the seven-month count was negative, although the females, in common with the females from all the previous monthly observations, showed an extreme reduction in the number of eggs laid, a fact which was not evident with random-trapped beetles caught at the same time. These trials are being restarted on Coconut Palms with the addition of Gammexane, Aldrin and Dieldrin dusts to the treatments.

(*b*) *The Coconut Grasshopper.* Various species of Tettigoniids are the cause of severe defoliation and subsequent loss of yield in a number of localities in the Bismarck Archipelago. Probably about six species are involved, although the main ones are *Sexava nubila* and *S. nova-guineae*.

Some inquiries have been made into the possibilities of controlling the insects by aerial spraying but this does not appear to be practical under the conditions which obtain in the Territory. Similarly, power dusting, or spraying, from the ground proved difficult to carry out due to roughness of terrain, the isolated nature of many of the affected plantations and the difficulties of obtaining suitable machinery which will operate effectively under tropical conditions. There is some indication that soil treatment against the hoppers emerging from eggs, most of which are laid in the soil, is partially effective, but this is largely offset by the fact that *Sexava* is usually most harmful in areas where the rainfall is rather heavy. Treatment of the basal portion of the trunk also holds promise, since not only the emerging hoppers, but also the adult females have to return on foot to the crown after oviposition as they can only fly downwards or across from one palm to a contiguous one.

On the biological side, most work has been done to date with the Encyrtid (*Leefmansia bicolor* Waterst.) a parasite introduced to New Guinea in 1933 from Amboina. Prior to the war, it was found that this parasite was not well able to maintain itself in the field although it bred very easily in captivity. Since the war, on several occasions, outbreaks of *Sexava* have been brought under control by mass liberation of this wasp in New Britain and New Ireland and stocks are usually kept on hand in case they are required for sudden outbreaks.

Fig. 3.
Coconut frond damage caused by "Sexava" sp.
(Photo by J. J. H. Szent-Ivany.)

During recent months attempts have been made to establish in the Rabaul District, the *Strepsipterema* parasite of the mainland species of *Sexava, Stichotrema dellaterreanum* Hof. It will attack the local species, *Sexava nubila* Stol., but work with this project is hampered by the fact that the Strepsipteron is known only from the female and it would appear that the latter requires to be fertilized. Light-trapping on the mainland has revealed the presence of the hypothetical male of the species, a Myrmecolacid, but the matter of determining its host species is likely to be an extremely difficult one.

(c) *Coconut Leafminer* (*Promecotheca papuana* Cski.). There has been little occasion to deal with this beetle until recent months. It is normally only a minor pest kept under control by its indigenous parasites but, due to the action of the cosmopolitan Harvest Mite, *Pediculoides ventricosus,* in preventing the parasites from functioning effectively, the miner became a serious pest in parts of Fiji and New Britain prior to the war. In Fiji the position was permanently rectified by the introduction of the wasp *Pleurotropis parvulus* in 1933. In New Guinea, the only areas where the Hispid has been serious are at the western end of New Britain at several points on the north and south coast in areas of extremely heavy rainfall. *Pleurotropis* was introduced to New Britain from Fiji in 1937, principally to overcome a one-stage outbreak at Rabaul occasioned presumably by the extremely heavy ash deposit following the volcanic eruption in 1936 which must have sufficed to allow a one-stage condition to develop.

In the Rabaul area the introduction of *Pleurotropis* appears to have permanently reduced the host to an insignificant level. However, at Linga Linga on the north coast of New Britain, the parasite has never been entirely effective and several restricted one-stage outbreaks have occurred since its introduction. At Lindenhafen, on the south coast, it has been entirely effective until late in 1953 and now (early 1954), in the two localities, some four thousand acres are seriously affected resulting in a current loss of production of some 30 per cent. at Linga

Linga and 50 per cent. at Lindenhafen, which latter figure may rise to 75 per cent. or more within the next few months.

The danger of this breakdown, of course, is that plantations and Native groves in the area are well separated and there is a distinct possibility that *Promecotheca* may have been wiped out in many of them and they may thus be subject to the risk of re-infection by coastal shipping from the outbreak areas. This condition is known to occur on one island plantation several hours' sailing to the west of Lindenhafen. To this end stocks of *Pleurotropis* are being built up in the laboratory to have available for immediate distribution in case of such an eventuality.

2.—*Cacao.*

This crop is affected by an increasingly wide range of insect pests, the eventual status of many of which, as mentioned before, it is not possible to predict. The two types of insects on which most work has been carried out are the Stem Borers and the Capsids.

(*a*) *The Stem Borers* comprise the Weevil Borer, *Pantorhytes plutus* Obert., and the Longicorn Borer, *Glenea aluensis* Gah. Both these genera are well represented in the Territory by a number of species and, no doubt, other species will attack Cacao as it becomes more firmly established and widespread. Already two other species of *Pantorhytes* have been associated with Cacao on the mainland of New Guinea.

Detailed studies of the bionomics of both species have been carried out, the work having been initiated by Mr. B. A. O'Connor, now Government Entomologist, Fiji, and completed by the writer. The Weevil Borer is the more serious of the two species, but, due to the fact that it is apterous and is not provided with an ovipositor, it is not likely to become serious until the current young plantings mature. For this reason work on the control of this species can safely be deferred until a later date although the characteristic of smooth bark has been incorporated into the cacao breeding and selection programme.

Investigations of an indigenous Dryinid parasite of both borers indicate that there is little hope that it can be used successfully against them.

Hand-collecting of the adults of *P. plutus* may eventually be of some help as they feed on the young bark and leaf petioles and have a quite marked early wet season population peak. Being apterous, banding experiments using Ostico mixed with a 10 per cent. D.D.T. powder spread for a distance of some six inches along the main trunk have produced a high mortality in adult beetles obliged to walk over the bands after a lapse of almost one year. The Longicorn Borer is not amenable to such treatment as it is semi-nocturnal in habits and flies very readily.

Several other species of Lamiids also attack Cacao in New Britain but they are as yet localized in their attack. They belong to the genera *Monohammus, Dihammus* and *Batocera.*

(*b*) *Cacao Capsids.*—These comprise a group which was only recorded from Cacao in New Guinea in 1950. They have been described as belonging to two new genera and four new species, as follows :—

1. *Parabryocoropsis typicus* Ch. and Car.
2. *Parabryocoropsis cheesmanae* Ch. and Car.
3. *Parabryocoropsis duni* Ch. and Car.
4. *Pseudodoniella pacifica* Ch. and Car.

Their action is precisely similar to that of the West African Cacao Capsids although, since their attention has been paid to this crop for only such a short period, it is not possible to say how quickly and to what extent they will develop the habit of feeding on the young shoot growth. In recent months a further Capsid, *Helopeltis clavifer* Walk., has been found attacking Cacao fruit in Papua. Since the Cacao has barely reached the stage of bearing there the rapidity with which the insect has adapted itself to the plant is remarkable.

Studies of the bionomics of the principal species of Capsid, *P. typicus,* have largely been vitiated by the fact that the insect, especially in the adult stage, is extremely difficult to handle in captivity. Given even such presumably suitable conditions as caging in large gauze cages enclosing Cacao pods on the tree, it is seldom that the females survive long enough to even commence oviposition, while males are even

Fig. 4.
Dusting to control the cacao capsid " Parabryocoropsis typicus " Ch. and Car.
(Photo by J. J. H. Szent-Ivany)

more delicate. This, of course, has made it impossible to carry out insectary insecticide trials satisfactorily.

Field trials on the control of the Capsids have been of limited extent. Since there is no indication that oviposition by *P. typicus* occurs elsewhere than in fruit tissue, it has been possible to achieve good control by complete defruiting in blocks of young Cacao. However, this is only a temporary expedient and is only possible of application when the trees are just coming into bearing.

For various reasons dusting is preferred to spraying under local conditions and quite good control has been obtained using knapsack-type dusters with Gammexane containing 1.3 per cent. G.I. BHC. While the results are not fully conclusive yet, it appears that two dustings applied at a four-weekly interval prior to the onset of the wet season (i.e. between August and October) will give a reasonably good measure of control at relatively low cost. D.D.T. applied at standard strengths, either as a dust, emulsion or dispersible powder, does not appear to be as effective, while the Gold Coast practice of controlling Capsids by painting the point of ramification of the trees with a concentrated D.D.T. paint is ruled out by the different growth habit of the types of Cacao grown in the two areas and the more or less stationary habit of the local species.

(c) *Miscellaneous Pests.*—These are at present classified as such, not because they cannot be serious in effect, but because they are extremely localized in distribution, some even being confined to one or two plantations to date. However, the number of such insects is gradually increasing from year to year as the area under Cacao expands and ages. General observations only have been made on the bionomics and control of the principal species. These can be divided into stem borers, bark eaters and defoliating insects.

The borers comprise principally Lamiids which attack ageing or debilitated trees; the main ones being *Dihammus* and *Monohammus* spp. and *Batocera nebulosa* Bates. The Zeuzerid *Zeuzera coffeae*, also occasions some damage but in none of these cases have satisfactory and practical control

methods been evolved yet. Localized attack by the Cacao Termite, *Calotermes papuana* Desn., may occasionally be severe, but it is readily controlled by the introduction of White Arsenic powder to the galleries.

Bark-eating species are limited in number and the principal one is the Xyloryctid Moth, *Pansepta teleturga* Meyr. This insect is semi-gregarious and may occur in numbers up to as many as one hundred larvæ on a single branch which usually results in branches of three to four inches in diameter being killed. As it is so far confined to an area comprising only three plantations, limited work has been done on the bionomics and control of this species. There it good reason to believe, however, that it will be amenable to control by cultural means. Since Cacao has certain definite shade requirements, it has been noted that the moth is almost invariably worse where these requirements are inadequately met.

Foliage-eating insects are numerous and, at times, cause extensive damage. Their action is both direct and indirect, directly by defoliation and indirectly by causing excessive proliferation of the branches which produces an ill-formed tree, prone to breaking in heavy rains and difficult of access for harvesting. The principal species involved are :—

Collembola.—*Salina celebensis.*

Coleoptera.—Curculionidae. *Pantorhytes plutus, Exopthalmida glauca.*

Chrysomelidae. *Rhyparida* spp., *Monolepta semiviolcea, Microlepta* spp.

Lepidoptera. Geometridae *Ectropis bhurmitra.*

Noctuiidae. *Achaea janata.*
Prodenia litura.

Direct fruit damage is of little current importance and, while the serious Cacao Moth (*Acrocercops cramarella*) of Java has been recorded from the Territory previously, it has not been in evidence since the War. Both the Collembolon and the Lepidopterous species are readily controlled by standard D.D.T. and BHC preparations while the Weevil Borers, and especially *P. ruralis* are rather resistant to D.D.T.

3.—*Miscellaneous Crops.*

Other agricultural crops are, as yet, little cultivated in the Territory. For this reason work in this direction has largely been confined to determining the species of insects attacking the limited number of crops under cultivation. The principal crops concerned include rice, kenaf, manila hemp, cotton, peanuts, citrus, green manure and cover crops, etc.

(B) Horticultural Crops.—

(1) As with miscellaneous agricultural crops, work has largely been restricted to determining the species involved. In some instances with vegetable crops in wide use, trials with standard insecticides (D.D.T., BHC, Toxaphene, etc., and more recently Aldrin and Dieldrin) have been carried out. The pests thus experimented with include such species as Bean Fly (*Melanagromyza phaseoli* Coq.) Corn Borer (*Pyrausta damoalis*) Cutworms (*Prodenia litura* and *Spodoptera mauritia, Heliothis armigera*), etc.

(2) *Giant African Snail.* The principal work in this section comprises a rather detailed study of the life-history, ecology and some methods of control of the Giant African Snail, *Achatina fulica hamillei* Bowdish. This pest was introduced to various parts of the Territory during the Japanese occupation. There is some difference of opinion as to the true economic status of this snail, but it is probably more a horticultural than an agricultural pest and causes considerable and insidious losses in Native food gardens and European vegetable and flower gardens. There is, however, a distinct possibility that it could become of some agricultural importance in certain crops if they were grown on a sufficiently large scale. Such crops could feasibly be papaw, peanuts, citrus, castor oil, kenaf, etc.

Despite the lack of adequate quarantine facilities, the Territory has been fortunate in that, apart from one or two minor instances, the snail has not greatly increased its spread since the War. The main centres of infestation are still the original ones—Kavieng District in New Ireland, the Rabaul District in New Britain and the Hansa Bay District on the north-east mainland coast. In several instances, prompt recognition of an introduction has permitted extermination of the pest following an inadvertent introduction.

A pronounced feature of the snail's activities is its immense reproductive capacity immediately following its intro-

duction to an area. There is some indication that this initial impulse declines after some five to ten years and it is a fact that gigantism is much less frequently encountered after the first five years. Nevertheless, the snail is unlikely to decline to a completely uneconomic level in suitable environmental areas where susceptible crops are grown on a small scale.

Life-history observations on pairs and groups of individuals have been carried out over a period of two and a-half years, at which point they had to be discontinued due to lack of staff. At the same time ecological observations were carried out on such points as feeding habits, duration of aestivation, resistance to desiccation, rate of spread and many other points.

Completely effective control of the snail has not been possible to achieve although the effectiveness of natural barriers in hindering its spread has been demonstrated on many occasions. Such barriers include mountain ranges—even of limited height—kunai (*Imperata arundinacea*) flats, rivers, etc.

It is hoped at a later date that predators will be obtained. Earlier attempts by the writer to collect several predators in East Africa were negatived by the preceding lengthy dry period which had sent virtually all the snail population into aestivation at the time of the visit.

Methods of chemical control tried have relied on the attractiveness of Metaldehyde, the lethal quality of Calcium Arsenate and the repellant nature of Creosote (or Coal Tar). It has been found that a 3 per cent. dispersion of Metaldehyde in relatively old sawdust is both attractive and lethal and considerably less expensive than proprietary mixtures. It has been principally used in the Territory to protect young Cacao seedlings planted at stake as these are most susceptible to snail attack up to the time they form their first hard leaf (eight to ten weeks). This mixture has been used quite a lot to protect plots of especially susceptible plants, such as legumes, on Experiment Stations. The incorporation of Metaldehyde with cement as briquettes has also been tried but is too slow acting. Spraying with the poison dispersed in water using a detergent proved ineffective presumably because it was not possible to get a lethal dosage on to the plant.

Calcium arsenate washes applied to tree trunks, boulders, etc., were effective to a limited degree, but did not appear to stand up well to the heavy rain of the wet season when the snail is most abundant and destructive.

For the protection of limited areas of vegetable garden the most effective method was found to be to enclose the area with 6-inch planks, placed edgewise and painted with crude creosote. Even in wet weather it was found that the repellant qualities will last from three to four weeks and, while relatively inexpensive, very few snails will cross the barrier. Trials with DNOC showed that, while effective, it has not the persistent qualities of creosote.

In areas of high snail density it is still, however, necessary to regularly hand pick if the numbers are to be kept within reasonable numbers outside the specially protected areas, even if only from the sanitation viewpoint. For instance, in the writer's garden, approximately 1½ acres in extent, the daily picking, depending on the preceding day's rainfall, will vary from 500 to as many as 3,000.

One of the most effective measures, not in keeping snail numbers down but in reducing the amount of damage that is done has been found to be in utilizing a knowledge of the plants which the snails will or will not attack. By suitably disposing one's flower or vegetable garden in such a manner that the susceptible plants are the last exposed to the snails' attack, it is possible to keep the damage to a minimum. As an example the following few susceptible flowers and vegetables may be quoted :—

Flowers.

Susceptible.	*Immune.*
Zinnias	Gerberas
Marigolds	Dianthus
Liliaceae	Gladiolus

Vegetables.

Susceptible.	*Immune.*
Cruciferae	Spinach
Cucurbits	Spring Onions
Mint	Parsley
Brinjals	Beans & Tomatoes (if staked)
Carrots	
Lettuce	Corn

It is possible also on occasions to make use of catch crops. An example of such a plant is radish, which is an extremely quick grower, gives good shelter to the snail during the day and thereby attracts them away from nearby susceptible but more useful plants, especially vegetables.

Apart from Calcium arsenate, trials with standard insecticides have had negative results, as one would more or less expect. Aestivation studies have shown that in extreme cases snails are able to remain dormant for as long as twelve months and still recover. Accordingly, snails fed with plant material treated with materials repugnant to them simply withdraw into their shells, form an epiphragm and emerge at varying intervals until acceptable food is available for them. An interesting fact worth investigating is the marked non-susceptibility of tobacco to the snails.

(C) Insects of Stored Products.—

Losses in stored products in the Territory are particularly high, especially in Native imported foods such as brown rice, wheatmeal, dried peas, etc. Losses in European foodstuffs such as polished rice and flour are less but are, nevertheless, of a continually recurring nature. The high incidence of these pests is partly due to the consistently high temperatures throughout the year but appears to be largely due to the generally poor bulk storage conditions which prevail, these being still based principally on ageing War Disposals materials.

While all the cosmopolitan species appear to be present in the Territory, the bulk of the damage is done by the Grain Weevils and the Flour Moth (*Ephestia cautella* Walk.). The Bean Weevil (*Bruchus chinensis L.*) also causes much loss in dried peas used for Native rations and in legume seed generally. In the latter case good control has been obtained by dusting with minute quantities of BHC with no apparent adverse effect on viability. Limited trials with the control of *Ephestia* by the application of a concentrated Gammexane wash have been quite successful although the use of Gammexane Smoke generators, even in such buildings as Quonsett Huts, which would appear to be eminently suitable, has had little effect.

(D) Forests and Forest Products.—

Work in this field has been of an extremely limited nature as the main forestry centres are situated too far away. Some minor investigations, in connection with a nearby re-afforestation scheme, include—

(*a*) protection of seed beds from the Gaint Snail and the protection of the young seedlings from the same pest;

(*b*) control of the Teak Moth (*Hyblaea puera*) in Teak seedlings using D.D.T. and BHC preparations; and

(*c*) the use of Chlordane as a dispersible powder to control Mole Crickets [*Gryllotalpa* spp. (*G. africana?*)] in nurseries.

No opportunity has occurred to investigate the damage caused by the large Weevil Borer (*Vanapa oberhuri*) in the pine forests in the Highlands.

(E) Insects of Pasture and Field Crops.

Little occasion has arisen to investigate these types of problems to date. As mentioned above crops like corn and sorghum can still be considered as horticultural crops. Rice is cultivated on a much larger scale although still relatively small, but it does not appear to suffer greatly from the various serious Stem Borers which are present in South East Asia, the Philippines and Indonesia, although several of these are known to occur in the Territory. Perhaps the greatest spasmodic pests of this crop are the Coreids, *Leptocorisa* spp. which sometimes cause serious loss of grain. On small plots, successful control of these has been obtained with knapsack dusters using proprietary D.D.T. preparations of standard strength.

Pasture crops are at present of little importance in the Territory although a White Grub, *Lepidiota* sp., has been causing some damage to turf in the Highlands during the past few years. No opportunity has occurred to investigate this pest.

(F) Insects of Medical and Veterinary Importance.—

(1) *Medical.*

This field is at present outside the scope of the work of the writer and attention has been confined to obtaining determinations of the commoner pest species of mosquitoes, sandflies, etc.

(2) *Veterinary.*

This field is at present also outside the scope of the writer and studies have likewise been limited.

An interesting new record is the determination of the Old World Screw Worm (*Chrysomyia bezziana* Vill.) as being wide spread in the Territory and the islands. However, from verbal accounts, it appears likely that its presence is a long standing one.

While cattle have been only slowly re-established in the Territory since the War, it is interesting to note that the Buffalo Fly, although known from New Britain for at least the past thirty years, is currently of singularly little importance. On the other hand the Stable Fly is frequently quite abundant and irritating.

(G) Household Insect Pests.—

As is usual in the tropics, and especially in the Territory where the housing conditions are generally of a primitive nature, household insect pests assume a position of considerable importance. The principal types which are concerned are the Cockroaches and Ants (*Periplaneta americana* and *P. australasiae* and *Pheidole oceanica* and *Pheidole* sp.). Experimental work on these species has been confined to finding a suitable method of control in houses. Chlordane has given by far the best results to date. Dosages and treatments sufficient to cope with ants are such that Cockroaches are unlikely to be found in houses where the former insects are kept reasonably well under control. Trials with samples of Aldrin and Dieldrin have been initiated but have not yet yielded positive results. The common Silverfish does not appear to be capable of assuming a role in the Territory similar to what it can assume under more temperate climatic conditions.

(H) Biological Control.—

Opportunities for working on this subject, apart from introductions against the Rhinoceros Beetle, have been limited although it is an undoubted fact that New Guinea offers unlimited scope for work of this nature. In fact, the breeding out of larvæ of insects of minor economic importance is often seriously hindered by the presence of parasites and hyper-parasites. As an example, efforts to export to Fiji a species of *Apanteles* parasitic on a Coconut Moth *Agonoxena pyrogramma* Meyr. have been continually thwarted by the effectiveness of the control the parasite exercises.

A preliminary investigation has been carried out of the parasites affecting Sugar-Cane Borers in New Britain with a view to finding out whether any would be suitable for use in Mauritius. There appear to be two local species of Borers, a Crambid *Chilotraea terenellus,* and a Noctuid, *Sesamia grisescens.* From these five species of parasites have been reared, two Braconids, two Tachinids and an Ichneumon, most of which are not specific in their choice of hosts. A reasonable shipment of the Ichneumon, *Enicospilus* sp. has been made to Mauritius, but a smaller shipment of the larger Tachinid, *Carcelia evolans* was unsuccessful, due largely to the presence of a hyperparasite, *Exorbistobia* sp. Fam. *Encyrtidae.* While the two Apanteles are not uncommon, their shipment is rendered difficult by the fact that the pupal period is a week or less and the adults will not survive in captivity for more than twenty-four hours.

A shipment of the Tachinid, *Bactromyia frasseni,* parasitic on the Banana Scab Moth, *Nacoleia octasema* to Fiji was not successful.

(I) Insecticides.—

No facilities are available for formulating insecticides in the Territory and work on this subject has been confined to the control of individual species affecting economic plants using standard proprietary preparations, as mentioned under the various headings above. Much the same applies to the methods of application except that, under Territory conditions, it has been found that for the current major crops none of the types of power machines tried has been really satisfactory. This is largely due to the rough type of terrain over which the machines have to operate. For the control of pests in Cacao it has been found that dusting is generally preferable to spraying, a fact which is dependent upon the physique of the Native carriers, the simpler distribution problems and the fact that the normally very still air allows the dust to be satisfactorily placed in the position desired.

(J) Insects and Viruses. Insect Physiology. Population Dynamics.—

No work has been undertaken specifically on these subjects during the period under review.

(K) Taxonomy.—

The nearest approach to work on this subject has been an attempt to reconstruct the Departmental reference collection most of which was destroyed during the Japanese occupation. The shortage of staff has prevented any commencement of work on taxonomic projects. Even as far as a reference collection is concerned, progress has been confined to seeking determinations of species of some economic significance owing to difficulties of adequate storage.

(L) Quarantine.—

Little actual progress has been made in this aspect of entomological work due largely, again, to the difficulty of recruiting sufficient staff. It is, however, an extremely important problem owing to the marked discontinuous distribution of the more serious insect pests in the Territory.

As instances of the type of quarantine problems with which the Territory is confronted, the following may be quoted :—

(1) The Giant Snail is present in none of the main centres of the New Guinea Mainland or on Bougainville Island.

(2) The principal Cacao Capsids are not present in Papua.

(3) The Rhinoceros Beetle is not present on the Mainland or on Bougainville Island.

(4) The species of *Sexava* differ from one island to another : many similar examples could be added to this list.

In fact, in view of the multiplicity of shipping, both Native and European, which moves between the Mainland and the various islands, it is remarkable that no serious internal introductions have been effected in the postwar years.

Rural Broadcasts—I.

ANTHRAX

Anthrax is an acute infectious disease of livestock and man, caused by a specific bacterium known as the Anthrax bacillus (*Bacillus anthracis*). The Anthrax bacillus was the first bacterium to be recognized as the cause of a disease of animals or man. Under the microscope, it appears as a tiny cylinder, not very different from some of the common non-pathogenic air and soil bacteria.

When exposed to conditions unfavourable to its existence, the Anthrax bacillus forms spores—that is, it changes from an active to a dormant state. Live, growing Anthrax bacilli that pass from the body of sick animals on to the ground, usually form spores. These spores, which develop within the body of the Anthrax bacillus, are extremely small, oval-shaped objects similar to seeds, remarkable for their viability and very resistant to heat, cold, chemical disinfectants and prolonged drying. Experimental evidence has shown that Anthrax spores can still germinate after being stored for more than fifty years. Anthrax spores are likewise very resistant to high temperatures and will withstand boiling for several minutes. Nevertheless under field conditions Anthrax usually dies out after a few years, except in areas particularly suitable for its propagation.

Anthrax occurs in many countries throughout the world in certain restricted areas, that is, as a continually recurring enzootic disease. In Europe the incidence is greater among cattle than among sheep, but in Australia and South America sheep are more frequently affected. In New Guinea, pigs are most frequently affected.

Practically all animals are susceptible in some degree to Anthrax. Generally speaking, the susceptibility of various domestic animals in decreasing order is—sheep, cattle, horse, pig, dog and cat. Adult dogs are not very susceptible, but puppies can be readily infected. In some countries the disease is known to occur naturally in buffalo and deer.

Birds are generally very resistant to Anthrax, but a few species including ducks, sparrows and young pigeons may be affected.

Anthrax rarely spreads directly from animal to animal. Infection usually results from the ingestion of contaminated food. Infected animals may excrete the organism in the urine, fæces, milk, saliva or nasal discharge, and at the time of death, and for some time afterwards, bloody infected fluid exudes from the natural openings and soils the neighbouring ground. Animals ingesting pastures or drinking water contaminated in this way may then develop Anthrax.

In pigs and dogs infection commonly results from the ingestion of flesh from Anthrax carcasses.

Anthrax may spread from one country to another, or from an enzootic area to a free one through the interchange of infected objects closely associated with animal life, including hides, hair, wool, bonemeal, fertilizer, hay and other materials.

Following contact with infected food the bacilli are first found in the tissues of the throat. The chief factor determining the susceptibility of an animal species appears to be the speed of spread of the organism from this site to the rest of the body. In susceptible species such as sheep and cattle, the bacteria quickly invade the blood stream and cause sudden death of the host. In pigs, which are more resistant, the disease is less acute because the bacteria usually remain localized in the tissues of the throat, and it may be difficult to find the organism in the blood stream.

The actual cause of death in Anthrax is a debatable question. The Anthrax bacilli do not kill by toxin production, as many other bacteria do, but there is a certain amount of evidence that they interfere with oxygen supplied to the tissues.

The symptoms of Anthrax vary according to the species of animal affected and the acuteness of the attack. The average period of incubation (that is, the period of time

elapsing between exposure to infection and the appearance of symptoms), under natural conditions is not definitely known, but it is believed from experimental evidence to vary from twenty-four hours to five days or much longer.

The disease may occur in a per-acute, acute, sub-acute, or chronic form.

The per-acute form, sometimes called the fulminating type, is characterized by sudden death, as from a stroke. The onset of the disease is so sudden and the course so rapid, that few, if any, clinical symptoms are observed. The usual picture associated with this form is one of cerebral apoplexy—sudden staggering, collapse, a few convulsive movements, and death. A blood stained discharge from the mouth, nose and anus may also be observed. This form is most common in cattle and sheep, occurring at the beginning of an outbreak. The sudden death of cattle, sheep and horses in known Anthrax territory, should always be regarded with suspicion.

The acute form usually terminates in death in a day or two, while the sub-acute form may lead to death in three to five days or longer, or to recovery after several days. In these forms of the disease there is an early stage of excitement, which is soon followed by depression, stupor, spasms, evidence of respiratory and cardiac distress, staggering and death. During the course of the disease, the body temperatures may reach 107 degrees Fahrenheit, pregnant animals may abort, rumination ceases, and in milking cows the milk secretion is greatly reduced. Bloody discharges from the natural openings are common (although they may occur in other diseases too) and soft swellings that pit on pressure may develop in different parts of the body. Just before death the temperature falls below normal, respiration becomes extremely laboured, and the mucous membranes become dark blue in colour.

Chronic Anthrax may occur in pigs, affecting the lymph glands of the throat or gut, and this is usually recognized only at post-mortem examination. Usually, however, pigs show more acute forms of Anthrax in an outbreak. Some of the animals may be found dead without having shown any previous signs of illness, others of the group may show rapidly progressing swellings about the throat, which in some cases cause death by suffocation. A relatively large percentage may become visibly sick for a few days, with or without swellings about the throat, and recover.

Any animals dying in known Anthrax areas after showing symptoms just described, should be suspected of having Anthrax. Such animals should not be submitted to post-mortem examination, as opening of infected carcasses exposes both the operator and the environment to dangerous Anthrax spores. The following specimens should be submitted for laboratory examination :—

From *pigs* or *horses,* forward smears of fluid from the swollen tissues of the throat ; and

From *cattle, sheep* and *goats,* forward four blood smears from an ear vein, and remove an ear and place in a sealed tin for forwarding.

Treatment of affected animals with immune serum or with drugs has not been recommended in this country and will be the subject of investigations by the Department.

McGarvie Smith Vaccine is available for vaccination in the Territory. It is used for the prevention of Anthrax in sheep and cattle in Australia, and has proved effective for pigs in the Central Highlands of New Guinea. Full instructions are supplied with the vaccine and they should be strictly followed.

Vigorous hygienic measures should be adopted when an outbreak of Anthrax occurs. Every precaution should be taken to avoid contamination of the premises or pastures with blood or other fluid escaping from infected animals.

Prompt deep burial is quite a safe method of disposing of unopened Anthrax carcasses, where lack of fuel or danger of fires prevent cremation. Burning is, however, by far the better method when it can be adopted. In the absence of wood fuel for this purpose, carcasses can be effectively incinerated by spraying with waste sump oil. Burning must be complete ; charred bones may contain living spores in the marrow. Care should also be taken to see that all the surface soil around the animal which may have become contaminated with discharges, is shovelled up and placed on the fire.

Rural Broadcasts—II.

METHODS OF STORING PADDY AND MILLED RICE, AND PROTECTION OF THE STORED PRODUCT

This talk is an extract from the report of Mr. W. Poggendorff, Chief of the Division of Plant Industry in the New South Wales Department of Agriculture and an expert on all phases of rice production, who visited the Territory during March and June, 1952, making a survey of the rice industry in the Territory. As rice, like most food products, presents a considerable storage problem in this Territory, the chapter from his report dealing with this subject is being presented for the interest of rice growers.

Successful storage of both paddy and milled rice requires :—

(1) Reduction of moisture content to within safe limits.

(2) Maintenance of low moisture content.

(3) Protection from insects and rodents.

Paddy is easier to store safely than milled rice.

Moisture content is by far the most important single factor. The maximum permissible moisture content varies with temperature and storage conditions.

Ideally, storage for paddy or milled rice should :—

(i) Have the physical strength to withstand the pressure of the grain.

(ii) Be designed to facilitate filling and emptying.

(iii) Be weatherproof and prevent entrance of water either as liquid or vapour.

(iv) Be free of cracks and flaws which cannot be cleaned out and afford harbour for insects.

(v) Be capable of effective and economical fumigation.

Perhaps the ubiquitous oil drum affords the readiest efficient means of small-scale storage in the Territory.

A.—PADDY.

Many Native peoples harvest their crops in the form of small hand-sheaves consisting of 50 to 100 heads with a few inches of stem still attached; these are hung, well spaced, under ventilated shelter. The initial moisture content may be dangerously high, but rapidly attains equilibrium with atmospheric moisture; ample air circulation prevents heating and resultant damage. Moulds can still occur if the average moisture content of the air is high and under such conditions the paddy is best threshed after thorough drying in the sun and stored in drums to prevent re-absorption of moisture. Frequent inspection is necessary and further parching in the sun may be needed; this is usually accomplished by spreading the paddy in a thin layer on rock, sheets of iron, concrete floors or even clean earth threshing floors, and stirring at intervals. These principles are obviously well understood by some Territory Natives.

In all tropical countries approximately 13.5 per cent. moisture is considered the maximum safe moisture content for paddy to be stored in bulk, possibly up to 14 per cent. for paddy in bags in small stacks or in baskets. The premissible moisture figure rises with decreasing average temperature; for instance, 14.5 per cent. in southern United States of America, 16 per cent. in southern New South Wales.

Great difficulty occurs during wet harvest periods or under naturally high atmospheric humidity in reducing moisture to within these limits and in commercial practice, it becomes necessary to employ forced ventilation of bins, sheds or silos, or special drying equipment. Such containers should be as air-tight as possible, and for forced ventilation a perforated false floor should be provided, or numerous air ducts. Paddy which has been heated may be cooled by forcing normal air through it, but little drying occurs unless the air is at least 10

degrees Fahr. higher in temperature than the paddy. For this reason some provision is usually made for heating the air to be forced through the grain, usually by running the air duct between the compressor or fan and the bin through an enclosed fire.

Commercial mechanical driers are an elaboration of this principle : the paddy or other grain is elevated to a hopper and may flow down in a continuous thin sheet, regulated at the base, between wire mesh screens through which hot air is forced, or in a stream regulated down a baffled enclosed duct, open only at the top and bottom, through which hot air is forced from below.

By whatever means paddy is dried particularly if by parching in the sun or by hot air, great care should be taken not to reduce the moisture content too rapidly or internal cracking (checking) of the grain will occur, resulting in a higher proportion of broken rice on milling. Four per cent. reduction in any one operation within twenty-four hours is considered the permissible maximum.

B.—MILLED RICE.

Most of the foregoing remarks apply equally well to milled rice, but because the latter has lost the insulating effect of the husk, permissible maximum moisture content must be reduced at least 1 per cent. A safe milled rice moisture content for storing under average Territory conditions would be no higher than 12 per cent. and preferably 10 to 11 per cent.

It must be admitted that this objective is difficult to attain without artificial means; failing suitable equipment, storage should be in the paddy stage which allows slightly more latitude and milled rice should be promptly used to avoid deterioration.

Dry paddy will keep indefinitely, as will also completely milled rice, but brown and undermilled rices are subject to rapid deterioration by oxidation of the germ oil and consequent rancidity, unless they are dehydrated to less than 5 per cent. moisture and sealed hermetically.

Milled rice is much more susceptible than paddy to infestation by weevils, grain moth and other insects, but both need protection, particularly under conditions of high humidity and temperature. Insect and rodent-proof storage, in which grain may be fumigated if necessary, is desirable but often difficult to provide unless sheet iron is available for lining wooden bins. Concrete is excellent provided it is damp-coursed to prevent rise of ground moisture.

Where difficulty is experienced in cleaning out the container thoroughly, the empty container may be sprayed with a residual spray such as D.D.T., 2.5 per cent., but only in the case of paddy storage.

Fumigation of infested paddy for milled rice may be carried out with the usual foodstuff fumigants—carbon tetrachloride, ethylene dichloride, ethylene dibromide, carbon disulphide—at the rate of 3 to 6 gallons per 1,000 bushels, according to circumstances, and with all necessary precautions against risk to life.

THE CUPMOTH *SCOPELODES DINAWA* B. BAK (Family *Limacodidae*) AS A PEST OF MANILA HEMP AND MANGO.

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THE larvæ of the Cupmoths (*Limacodidae*) are well known pests of various cultivated plants (Coconuts, African Oilpalm, Cacao, Coffee, Tea, Banana, Mango, etc.) in the tropical zone. Species of the Genera *Susica* Wlk., *Thosea* Wlk., *Setora* Wlk., *Orthocraspeda* Hmps., *Narosa* Wlk., *Altha* Wlk., and others have been recorded as polyphagous pests in the Oriental Region, species of the Genus *Parasa* from the Oriental and from the Aethiopian and of the Genus *Sibine* from the Neotropical Zoogeographical Region.

APART from a few data recorded by Frogatt (3), Dun (1, 2) and the writer (5), very little was known of Limacodidae as pests of cultivated plants in the Territory of Papua and New Guinea.

The larvæ of a fairly large species, *Scopelodes dinawa* B. Bak. were found recently by the writer, defoliating Mango (*Mangifera indica*) and Manila Hemp (*Musa textilis*) in the Morobe District of New Guinea.

Figures Nos. 1-3 show the serious leaf damage caused by the large fleshy caterpillars to Manila Hemp, as observed in the Markham Valley near Lae. Figure 4 shows the larvæ and Figures 5 and 6 illustrate the cupshaped cocoons of *Scopelodes dinawa* B. Bak. on the leaves of *Musa textilis*. The defoliation of *Mangifera indica* observed in Wau (Morobe Highlands) was also very severe. On most of the leaves only the midribs were left intact.

The larvæ, kept in a breeding cage, refused to feed but the breeding of the insects from cocoons was very successful. The first adult moths emerged seven days after collecting the cocoons. Of 44 cocoons collected on Manila Hemp 20 males and 24 females emerged in the course of four weeks. All 44 adults emerged from the cocoons after sunset between 7 p.m. and 2 a.m. Perfect specimens could be obtained only if the freshly emerged moths were killed and mounted as soon as their wings became stiff. Individuals left in the breeding cage for two to three hours, began to crawl and fly around rubbing the scales off their wings. The breeding cages had to be checked every 40 to 50 minutes to obtain a good series of perfect specimens.

The photoxenic larvæ prefer to feed at night and they rest during the day on the lower surface of the leaves. The fully grown caterpillars are up to 1¼ inches long and 7/16 inch wide. Four rows of spined hairy appendages cover the greenish-yellow thorax and the abdomen, two of which are on the lateral surface and two are on the dorsal surface, left and right from the longitudinal section (see Figure 4). On touching the caterpillars the spines cause a burning pain and skin irritation, as in the case of many other species of *Limacodidae* ("Nettle Caterpillars").

The semi-oval cocoons have a dirty greyish-brown colour, similar to that of dry fallen leaves. Their length varies from ¼ inch to ½ inch. The light brown coloured pupa lies in a slightly bent position in the roundish cocoon. The cocoons were found singly or in small concretions of two to four on the surface of Manila Hemp leaves (see Figures 5 and 6).

The adult moth shows a remarkable sexual dichroism. Typical for both sexes are the relatively long light brown coloured palpi, ending in greyish-black tufts. The resting moth keeps the palpi in a curved (crani-dorsal) position. The curved end of the abdomen protrudes between the two forewings (see Figure 7). The females are larger and more robust than the males. The male was described by Bethune-Baker in 1904 (*Novitates Zoologicae* 11., p. 384). The female was described by Hering in 1934 (4) with the remark: "the female, which probably belongs to this species" . . . Hering's suggestion is now proved by the fact that Bethune-Baker's description covers the morphological characters of the males

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Fig. 1.
General view of Manila Hemp damaged by " Scopelodes dinawa " B. Bak.

Fig. 2.
A detailed view of defoliation of Manila Hemp by " S. dinawa ".

Fig. 3.
A further view of the leaf damage caused by "S. dinawa".

Fig. 4.
Larvae of "S. dinawa".

Fig. 5.
Cocoons of "S. dinawa" showing aggregation on leaf of Manila Hemp.

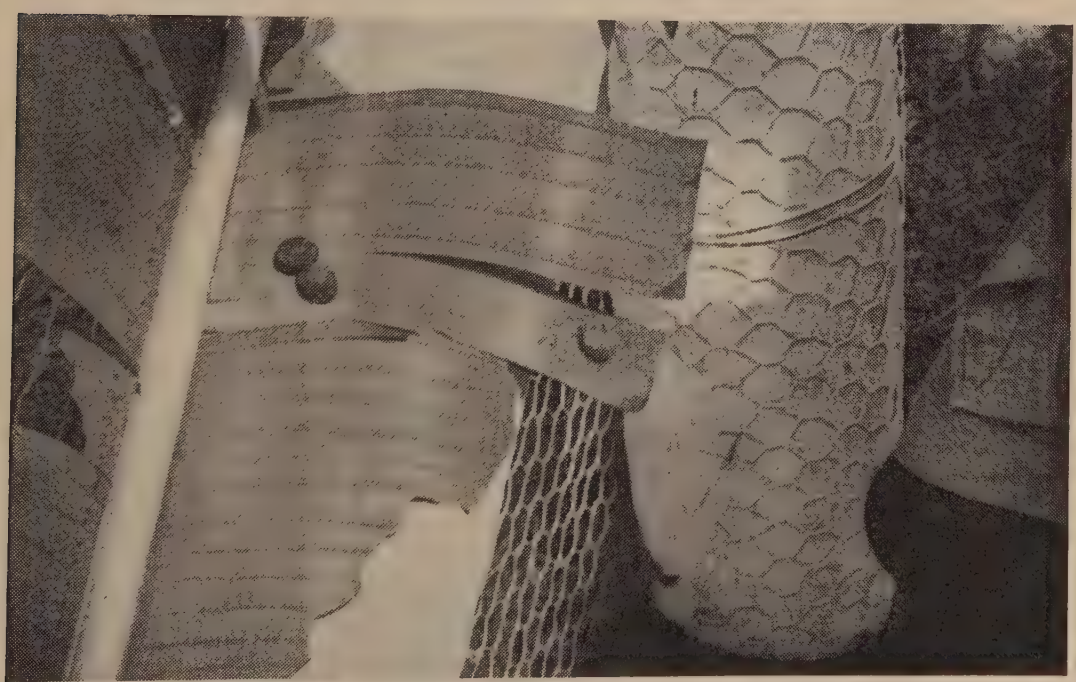

Fig. 6
Three cocoons of "S. dinawa" on leaf of Manila Hemp.

and Hering's those of the females, bred out by the writer from cocoons found in the Morobe District.

The larva and cocoon of *Scopelodes dinawa* B. Bak., to the best of the writer's knowledge, were unknown to the present date and its association with *Musa textilis* and *Mangifera indica* represent new economic records. An Indian (?) species of the Genus (*Scopelodes pallivittatta* Sm.) was recorded feeding on *Musa* spp. but this species is not closely related to *Scopelodes dinawa* B. Bak., which was recorded only from the Mainland of New Guinea. The forewings of *Scopelodes pallivittata* Sm. are decorated with an obliquely bent whitish band, while the forewings of *S. dinawa* B. Bak. are uniformly blackish-grey or greyish-brown coloured. *Scopelodes dinawa* B. Bak. shows a certain degree of individual variation in the colouration of the hindwings of the males and in the colour of the forewings of both sexes. The wing span of the male is $1\frac{1}{2}$ inches to $1\frac{3}{4}$ inches and that of the female $1\frac{3}{4}$ inches to 2 inches.

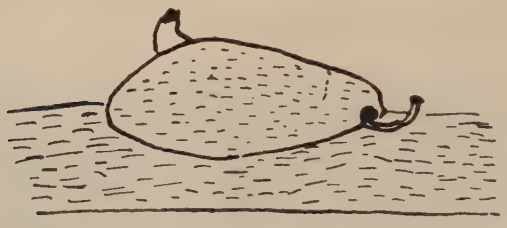

Fig. 7.
Adult of "S. dinawa" in resting position

From the ecological point of view *Scopelodes dinawa* B. Bak. seems to be a eurytopous and eurythermous species which is proved by the fact that it was found by the writer in the hot and humid coastal area (Markham Valley), in the cooler climate of the Morobe Highlands (3,400 feet above sea-level) and the pupæ were also resistant to the climatic conditions of the Eastern Highlands (Goroka, 5,200 feet above sea-level) where they had to be taken three weeks after the date of collecting. More than half of the adults emerged during the two weeks of the writer's stay at Goroka.

No parasites emerged from the forty-four cocoons in the Breeding Cage. This indicates that the species has no parasites in the Morobe Coastal Area or the parasites were out of season, allowing the building up of the moth's population. The larvæ are susceptible to 1 per cent. White Oil spray as proved by the owner of the defoliated Mango tree at Wau. It is very likely that any modern insecticide (0.1—0.2 per cent. D.D.T. Spray, Gamexane 10 Dust, Gamexane No. 7 Water Miscible Oil, etc.) would effectively control this pest.

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